OBSERVATIONS UPON THE ANATOMY OF HYLOBATES LEUCISCUS AND CHIROMYS MADAGASCARIENSIS.

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HYLOBATES LEUCISCUS.

As the opportunity of dissecting a gibbon is comparatively rare, it is hoped that a brief account of the results of the dissection of the young individual that recently died at the Philadelphia Zoölogical Garden may prove acceptable to the Academy. The gibbons, of which there are several species, are found, as well known, over a considerable area of Eastern Asia and the Malay Archipelago. Together with the gorilla, chimpanzee and orang, they constitute the group of Anthropomorpha, or anthropoid apes, of which they are the least anthropoid in their nature, resembling man more particularly in the character of the thorax. The gibbons are the smallest of the anthropoids, rarely attaining a height of more than three feet. The head is small, and the body and limbs are slender. They are the only anthropoids that exhibit ischial callosities. The most striking peculiarity of the animal externally is the length of the upper extremities, the fingers touching the ground when standing erect, which it often does. While they can run very rapidly, putting the sole of the foot flat upon the ground, which they often do, the genus is naturally arboreal in its habit, passing quickly from bough to bough in the forests which it inhabits, the movements being executed by means of its long arms with marvelous accuracy and force, twenty feet and more being covered at one bound.

Notwithstanding the small size of the gibbons, all observers agree as to the great volume of their voice, the cry of the Siamang, *Hylobates syndactylus*, being heard in its native woods miles away, its vocal sound being more powerful than that of any human singer. It may be also mentioned in this connection that the gibbon is the only mammal that can be really said to sing. The Wouwoo, *Hylobates agilis*, has been heard to emit at the London Zoölogical Garden the rising and falling scale of the semitones of the

octave.[1] The gibbon presented to the Academy by the Philadelphia Zoölogical Society, and upon the dissection of which this communication is based, is that known to zoölogists, according to Mr. Arthur E. Brown, Secretary of the Society, as *Hylobates leuciscus*, the silvery gibbon. As the anatomy of the gibbons is more or less well known, attention will only be directed to those parts of the economy of the animal under consideration which differ more particularly from those of man and the remaining anthropoids.

Muscular System.—Our gibbon, a young male, measured from the crown of the head to the heel 21.75 inches (55 centimeters). The length of the upper extremity from the shoulder to the tip of the middle finger was 17 inches (43 centimeters), that of the lower extremity from the hip to the tip of the middle toe only 13.25 inches (33.5 centimeters).

The muscles of the face were undifferentiated. In the cervical region the levator claviculæ was observed extending, as in the other anthropoids, from the transverse process of the atlas to the acromial end of the clavicle. The biceps arose by two heads, both, however, being humeral in origin, the small head arising from the lesser tubercle of the humerus instead of from the coracoid process, as in man. The latissimo condyloideus extended to the condyle of the humerus, not merely to the centre of the humerus, as stated by Hartmann.[2] The brachialis anticus was well developed, though its presence was not noted in the gibbon described by Bischoff.[3] The pronator radii teres arose by one head. There was nothing especially noticeable about the flexors sublimis and profundus digitorum. The slip from the tendon of the flexor profundus supplying the ring finger split, however, into two tendons, one of which, that ordinarily present, perforating the tendon of the sublimis, the other, the accessory one, being inserted into the first phalanx of the index finger. The latter disposition was probably an abnormal one. The part of the flexor profundus supplying the thumb was so completely separated from the rest of the muscle that it might almost be regarded as a distinct flexor longus pollicis, as is the case in man.

[1] C. L. Martin, *A General Introduction to the Natural History of Mammiferous Animals*, etc., 1841. Owen, *The Anatomy of Vertebrates*, Vol. III, p. 600.

[2] *Anthropoid Apes*, p. 164.

[3] *Beiträge zur Anatomie des Hylobates leuciscus.*

All of the muscles of the thumb—viz., the abductor, opponens, flexor and adductor pollicis—were present and well developed. In addition to the muscles of the little finger usually present, the abductor, flexor and opponens, it was also supplied by a distinct extensor proprius minimi digiti.

There was nothing particularly noticeable about the muscles of the dorsal surface of the upper extremity. The extensor indices split into three tendons, which supplied the ring, middle and index fingers. The extensor ossi metacarpi pollicis gave off two tendons, one of which passed to the metacarpal bone, the other to the trapezium, as is often the case in man and monkeys. The extensor primi internodii pollicis was absent; the extensor secundi was so inserted, however, as to act on both the first and the second phalanges of the pollex. The lumbricales were well developed. Of the contratentes digitorum, or the little muscles passing from the deep fascia over the metacarpal bones to the digits, two were observed, those supplying the second and fifth digits. The palmar and dorsal interossei were much developed, indeed remarkably so considering the size of the hand. The nerves of the upper extremity were exceedingly well developed, the median ulnar and radial especially so.

There was nothing especially to be noted about the muscles of the hip and thigh. The soleus was observed to arise from the fibula alone, and not as in man from both fibula and tibia. The plantaris, peroneus tertius and flexor accessorius were absent. The flexor longus hallucis gives a strong tendon to the big toe and three perforating tendons to the second, third and fourth toes, with lumbricales for the third and fourth toes only. The flexor longus digitorum contributes to the formation of the tendon of the flexor longus hallucis and supplies the third, fourth and little toes, the tendons supplying the third and fourth toes only being perforated by the two corresponding tendons of the flexor longus hallucis. The flexor brevis digitorum appears to supply the second toe only; it is perforated by the corresponding tendon of the flexor longus hallucis. The tendon to the fifth toe, corresponding functionally to that of the flexor brevis digitorum in man, appears when present to be derived from the flexor longus digitorum, as well as the deeper tendon from the same muscle already referred to. The muscles of the big and little toe, usually present, were noticed. Of the contratentes digitorum, that supplying the little toe was the only one observed.

The interossei were not as well developed in the foot as in the hand.

The Larynx.—In accord with what has just been said as to the voice being so powerful in the gibbon, one would naturally expect to find the larynx large and well developed, with its lateral ventricles dilated into enormous air sacs, as seen in the gorilla, chimpanzee and orang, or some modification of the hyoid apparatus such as occurs in the South American Howler, *Mycetes alouetta.* As a matter of fact, however, in our gibbon the larynx was not unusually large nor were the vocal membranes or ventricles specially well developed. Not a trace of a laryngeal sac was to be seen, either as sacs communicating with the larynx by the ventricles or by openings in the thyro-hyoid membrane, as is said to be the case in the Siamang.[4] Indeed, it is only in the latter species of gibbon that a large air sac has been found, the sac in this species being globular and to be regarded morphologically as a development of the thyroid hyoid membrane.

It must be admitted that the manner in which the loud voice is produced in the gibbons is not understood. That a laryngeal sac exerts but little influence in this respect is shown by the fact that the voice of the gibbon in which the sac is absent is as loud as in that in which it is present. Indeed, beyond the statement that a laryngeal sac acts as a resonator, there is little to be said as to the function even of the enormous sacs present in the remaining anthropoids.

Origin of the Great Blood Vessels.—The manner in which the great blood vessels are given off from the aorta in the gibbon differs from that in man. In the gibbon the aorta gives off an innominate and a left subclavian artery, the innominate in turn giving rise to the right subclavian and the two common carotid arteries, the disposition being similar to that observed in the orang.

Alimentary Canal.—There was nothing especially remarkable in the anatomy of the alimentary canal. The salivary glands were large and the rugæ of the palate were very prominent. The absence of a uvula was noted. The stomach was rather of a globular form, and resembled the human stomach much more than that of the

[4] Huxley, *Anatomy of Vertebrated Animals*, p. 412.

orang, which is much elongated. Valvulæ conniventes were absent; the patches of Peyer were, however, well developed. The urogenital apparatus did not present any remarkable peculiarity. The kidney exhibited, as in the case of the orang, only one papilla. There was one pancreatic duct and it opened into the duodenum close to that of the hepatic duct. The gall bladder was large and elongated, which was possibly due to the presence of gall stones. The vermiform appendix was present, measuring three centimeters (1¼ inches), but was both relatively and absolutely smaller than that of other anthropoids.

The Brain.—The brain in the present individual, as in the gibbons generally, was small. Unlike that of the Siamang,[5] however, the posterior lobes of the cerebrum covered completely the cerebellum, as was also the case in the brain of the silvery gibbon described and figured by Bischoff.[6] There was nothing particularly noticeable about the gyri and sulci, the principal ones being identified. It should be mentioned, however, that the calcarine fissure passed continuously into the hippocampal fissure, the gyrus fornicatus being separated, therefore, from the hippocampal gyrus, a disposition which, according to Ecker,[7] does not obtain in the genus *Hylobates*. The parieto-occipital fissure did not reach the calcarine, the two fissures being separated by the convolution known as the "deuxième plis de passage interne" of Gratiolet, or the "untere innere sheitelbogen-windung" of Bischoff. The ventricle was well developed and contained the hippocampus minor, and what appeared to be the remains of the eminentia collateralis. The brain of the gibbon resembles in some respect that of the *Semnopithecus* and in others that of the orang. Indeed, so much so is this the case, that it may be regarded as bridging over to a considerable extent the gap in cerebral development between the two.

The study of the organization of the gibbon, a *résumé* of which has just been given, leads to the conclusion, long since reached by the author, that the proposition advanced by the late Prof. Huxley, that the difference between man and the anthropoids is less than that between the anthropoids and the remaining Simiæ, except as regards the skeleton, is not true. The gibbon, for exam-

[5] Flower, *Phil. Trans.*, 1862, I, p. 185.
[6] *Op. cit.*, S. 76.
[7] *The Cerebral Convolutions of Man.* Translated by R. T. Edes, M.D., p. 76.

ple, as regards the general character of the brain, in the presence and absence of certain muscles, in the origin of the great blood vessels, and in other respects, resembles the lower Simiæ more than it does man. Further, the association of the four anthropoids in one group Anthropomorpha, as contrasted with the remaining Catarrhine or Cynomorpha, is an artificial, not a natural one, since there is no evidence to show that the anthropoids have descended from a common ancestor or are directly related genetically to each other. On the contrary, it is much more probable that each anthropoid has descended from some highly specialized Catarrhine—the gorilla, for example, from some Cynocephalus, Macacque, or like form; the gibbon from a Semnopithecoid one, and so on, the gibbon and orang being closely related on the one hand, the chimpanzee and gorilla on the other.

Chiromys madagascariensis.

The Aye Aye, so called on account of the natives uttering that exclamation the first time the animal was seen, was discovered by Sonnerat in the island of Madagascar about the year 1785, and was first described and figured by that naturalist.[8] For a long time after its discovery considerable difference of opinion prevailed among systematists as to its exact zoölogical position. According to Sonnerat the animal resembled a squirrel in some respects, in others a lemur. Buffon regarded it as a squirrel, Cuvier as a squirrel with quadrumanous affinities, Schreber as a lemur, etc. Indeed, it was not until the year 1863, nearly a century after it was discovered, that the Aye Aye was shown conclusively by the researches of the late Prof. Owen[9] to be essentially in its nature a lemur.

As our knowledge of the organization of the Aye Aye is somewhat limited, the only works treating of its anatomy, so far as is known to the author, being the monograph of Owen just cited and the later supplementary account of Peters,[10] it is hoped that the following observations will not be regarded as superfluous. The individual upon whose dissection the present communication is

[8] *Voyage aux Indes des Orientales et à La Chine.* Paris, 1806. Tome IV, p. 121. Plate 92.

[9] "On the Aye Aye," *Trans. of the Zoölogical Society.* London, Vol. V, 1866.

[10] *Ueber die Säugethiergattung Chiromys.* Abhdlg. d. Berlin, Akad., 1865.

based, though preserved in alcohol for several months, was in fairly good condition. It was a female, and measured from crown of head to the heel 45 centimeters (18 inches). The length of the upper extremity from shoulder to tip of middle finger measured 22.5 centimeters (9 inches), that of the lower extremity from hip to tip of middle toe 30 centimeters (12 inches).

Nervous System.—Owing to the softened condition of the brain, necessitating its removal enclosed in the dura mater, and to the subsequent unsuccessful hardening of the same, we have but little

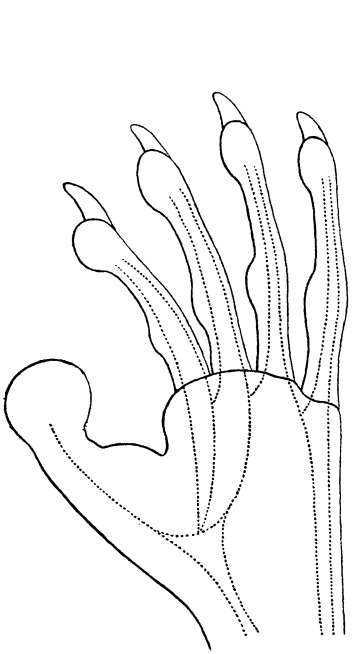

Fig. 1.

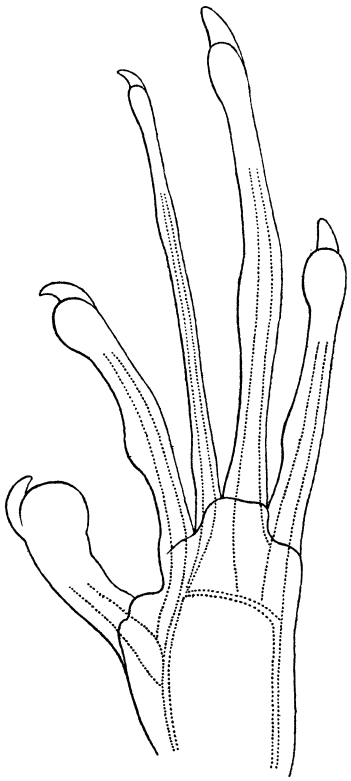

Fig. 2.

to say about it other than that in the general configuration, in the presence of a well-developed corpus callosum, in the simple character and paucity of fissures, and in the almost entire exposure of the

cerebellum, the posterior lobes of the cerebrum being so little developed, it resembled that described and figured by Owen. As the nerves of the extremities are not described by either Owen or Peters, it should be mentioned that, as regards the distribution of the nerves to the hand, it was observed that while the thumb and index finger were supplied by the median nerve, and the little and ring fingers by the ulnar nerve, the middle long slender finger was supplied by two branches which came from somewhat of a plexus formed through the union of the median and ulnar nerves, as shown in Fig. 2. It need hardly be mentioned that such a disposition is an unusual one, the little finger and ulnar side of the ring finger being supplied in five-fingered animals by the ulnar nerve, the radial side of the ring and remaining fingers and thumb by the median nerve. We shall see, however, presently that the middle slender finger is not only supplied by nerves derived from both the median and ulnar nerves, but by a greater number of muscles than ordinary.

Such disposition appears to be correlated with the function of the long middle finger which, as is well known, the Aye Aye makes use of in searching for its food, inserting it into pieces of wood containing the grubs upon which the animal preferably feeds. That the view just offered as accounting for the rich nervous and muscular supply of the middle finger is the correct one is further shown by the fact that in the case of the foot the big toe, second, middle and tibial side of fourth toe are supplied by the internal plantar nerve, and the little toe and fibular side of the fourth toe by the external plantar nerve (Fig. 1).

Muscular System.—As the muscular system of the Aye Aye has been described with considerable detail by Prof. Owen, attention will be directed more particularly to such muscles as were not noticed by that anatomist or which differed in regard to their disposition.

Of the muscles of the cervical region and upper extremity two were observed not mentioned by Owen. They are especially interesting as being found in all lemurs and monkeys, from the Aye Aye to the gorilla. These are the elevator claviculæ, extending from the transverse process of the atlas to the acromial end of the clavicle, and the latissimo condyloideus, passing from the latis simus dorsi to the internal condyle of the humerus.

The three short muscles ordinarily supplying the little finger and the four short muscles supplying the thumb were all well developed. The tendon of the flexor longus pollicis came off, however, from the tendon of the flexor profundus digitorum, the muscular belly of the pollicis being entirely undifferentiated from that of the profundus. The four tendons of the sublimis were perforated as usual by the four tendons of the profundus, four lumbricales being given off by the latter, as was observed by Owen, instead of three, the usual number. The interossei were well developed. The extensor muscles of the hand were four in number—an extensor communis digitorum supplying the four fingers, a second extensor situated beneath the communis supplying the ring and middle fingers, an extensor indicis supplying the index and middle fingers, and an extensor minimi digiti supplying the little and ring fingers. It will be observed, therefore, that the middle finger is supplied by three distinct muscles, an unusual number, the significance of which has been already referred to.

In addition to the four extensor muscles just mentioned, there were present two long extensors of the thumb, an extensor ossi metacarpi pollicis and an extensor secundi internodii pollicis.

Regarding the muscles of the lower extremity and more especially of those of the leg and foot, it may be mentioned that the tibialis anticus, the extensor proprius hallucis, the extensor longus and brevis digitorum were well developed. In addition to the peroneus longus and brevis, two other peronei muscles were observed not noticed by Owen, viz., a peroneus quarti digiti and a peroneus quinti digiti, the two muscles being inserted into the terminal phalanges of the fourth and fifth toes respectively. The two short muscles of the little toe and the four short muscles of the big toe were well developed. No trace was found, however, of the extensor brevis hallucis described and figured by Owen.

The tendon of the flexor longus hallucis enters largely into the formation of that of the tendon of the longus digitorum, the former supplying more particularly the big toe and the second and fifth toes, the latter the third and fourth toes. The only portion of the flexor brevis digitorum observed arising from the calcaneum was the muscular slip supplying the fifth toe, the three remaining slips coming off from the conjoined tendons of the longus digitorum and longus hallucis. All four tendons of the flexor sublimis were perforated by the tendons of the longus hallucis and longus

digitorum. Four lumbricales were present, as in the case of the hand, and the interossei were equally well developed.

The Viscera.—There was nothing especially noteworthy regarding the alimentary canal and its appendages other than what have already been described by Owen and Peters. The caput coli, however, at least in the specimen dissected by the writer, exhibited a decided constriction into two parts, a proximate portion corresponding to the cæcum and a terminal one, much narrower, about 2.5 centimeters (1 inch) in length, resembling very closely the vermiform appendix of man and the anthropoids.

The great blood vessels arose from the aorta, as described by Peters, the right subclavian and the trunk of the common carotids springing from an innominate, the left subclavian separately from the aorta.

No trace of a laryngeal pouch such as that described by Owen was observed, its absence being perhaps due to the fact that the animal was a female.

The uro-genital apparatus agreed essentially in its structure with that described by Peters, the urethra passing into the vagina through the anterior wall of the latter instead of perforating the clitoris, as is usually the case in lemurs. The clitoris and external orifice of the vagina were concealed externally by a circular fold of integument. It is an interesting fact that while the imperforate condition of the clitoris in *Chiromys* is exceptional among the lemurs, on the other hand the perforated condition of the clitoris, as in *Capromys*, is exceptional among the Rodentia, the urethra passing in the latter into the vagina.

According to many systematists, the lemurs, including *Chiromys*, together with the Simiadæ and man, are classed together as Primates; according to others the lemurs are separated from the Simiadæ and man and classed apart as half apes or Prosimii, and are regarded as being the ancestors of the Simiadæ, Insectivora, Cheiroptera and Rodentia. If the latter view be adopted, then the slender *Loris* may be regarded as the ancestor of the Simiadæ, *Tarsius* of the Insectivora, *Galeopithecus* of the Cheiroptera and *Chiromys* of the Rodentia, the rodent affinities of *Chiromys* being shown not only by its general resemblance to a squirrel and the form of its incisor teeth, but by the character of its alimentary canal and uro-genital apparatus.